MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

ENT4086 – DIAGNOSTIC TECHNOLOGY

(NE)

22 OCTOBER 2018
2:30 p.m. - 4:30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages with 4 Questions only.
2. Attempt **ALL FOUR** questions. The distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

QUESTION 1

(a) With the aid of a suitable diagram, discuss the operating principles of magnetic force microscopy (MFM).

[3+5 marks]

(b) With the aid of suitable diagrams, differentiate the basic principles of ion scattering spectroscopy (ISS) and Rutherford backscattering spectroscopy (RBS) in the contexts of *primary ions energy* and *surface sensitivity*, respectively.

[3+6 marks]

(c) With the aid of an energy level diagram, explain the working principles of x-ray photoelectron spectroscopy (XPS).

[3+5 marks]

QUESTION 2

(a) (i) Describe the **TWO(2)** main criteria for sample preparation for the transmission electron microscopy (TEM).

[4 marks]

(ii) Suggest **TWO(2)** different tools that are commonly used in sample preparation for TEM. Discuss briefly how each of the tools works.

[2+5 marks]

(b) (i) Explain why the x-ray fluorescence (XRF) technique is not able to detect light elements, with atomic number lower than 11?

[3 marks]

(ii) Explain why the Auger electron spectroscopy (AES) cannot detect hydrogen (H) and helium (He)?

[3 marks]

(c) (i) Discuss briefly the types of primary ions that preferably apply in analysis using secondary ions mass spectroscopy (SIMS) for each of the conditions as follows?

- To analyse electropositive elements
- To analyse electronegative elements
- To analyse organic and biological samples

[3 marks]

(ii) Suggest the type of operating mode of secondary ion mass spectroscopy (SIMS), *static* or *dynamic*, that one should use for in-depth distribution analysis of trace elements. Justify your suggestion.

[1+4 marks]

Continued...

QUESTION 3

(a) (i) Given that the binding energies of the electron shells: **K**, **L**, **M** and **N** are **18**, **2.5**, **0.43** and **0.05 keV**, respectively, determine the energy of the **Lβ** characteristic x-ray and the **KLN** Auger electron, respectively.

[4 marks]

(ii) **Figure Q3(a)** shows the Auger spectra of a thin film before and after argon (Ar) cleaning at the surface. Based on the spectra, discuss the changes of the *presence elements* and its *relative intensities* before and after the Ar cleaning, respectively.

[4+4 marks]

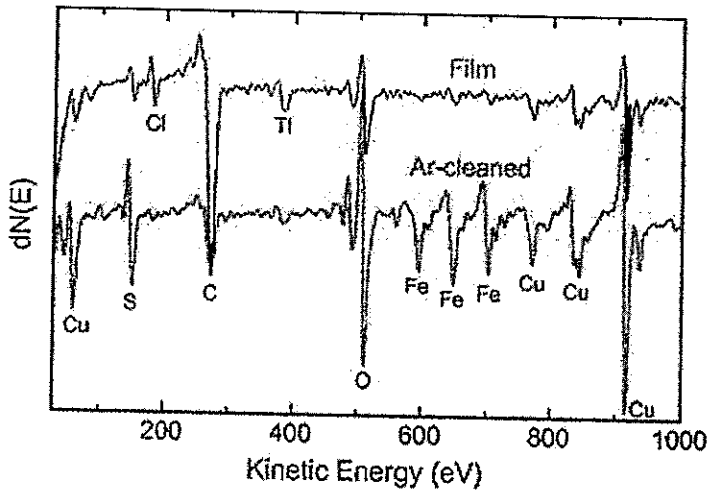

Figure Q3(a)
(Courtesy of L. Tan et al., 2009)

(b) **Figure Q3(b)** shows the Raman spectra of microcrystalline hydrogenated silicon (μc-Si:H) thin films deposited on glass substrate using radio-frequency plasma enhanced chemical vapor deposition (RF-PECVD) method at different substrate temperatures; 200, 250 and 300 °C, respectively. Answer the following:

(i) State the selection rule for a *Raman active* vibration.

[1 mark]

(ii) Given that the sample is measured using 514.5 nm line of an argon ion (Ar^+) laser at room temperature, calculate the wavelength of the Stokes line based on the peak observed in the spectrum for film deposited at 200° C.

[4 marks]

(iii) Analyse the spectra in the contexts of *crystallinity* and *strain* in the films, respectively.

[8 marks]

Continued...

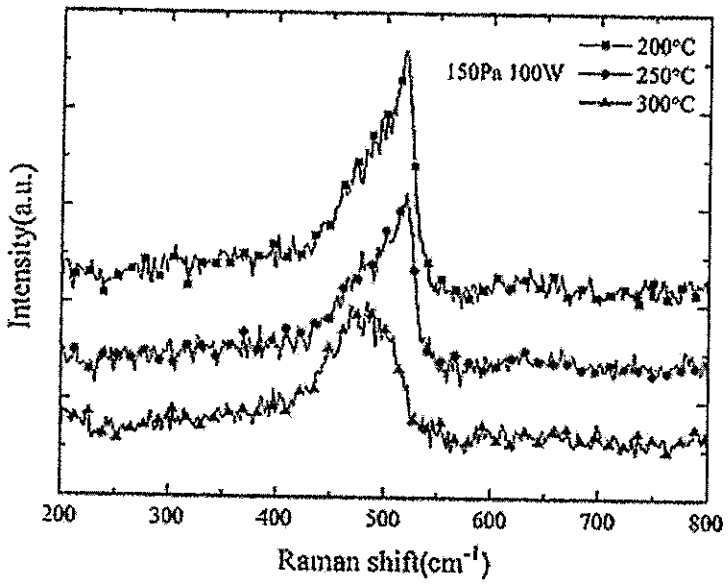

Figure Q3(b)

(Courtesy of X. L. Qu et al., 2017)

QUESTION 4

(a) **Figure Q4(a)** shows the scanning electron microscopy (SEM) images obtained in different modes: **(i)** secondary electron (SE) mode and **(ii)** backscattered electron (BSE) mode over the same region of tungsten tetraboride (WB_4) particles sample. Answer the following:

(i) Discuss the interpretation differences between an *SE mode* image and a *BSE mode* image.

[6 marks]

(ii) Evaluate the surface morphology of the sample in the contexts of *shape* and *size* of the particles, respectively.

[4 marks]

(iii) With clear justifications, comment on the *elemental distributions* in the sample based on the BSE image. *Given the atomic number, Z, of B(Z=5) and W(Z=74).*

[4 marks]

Continued...

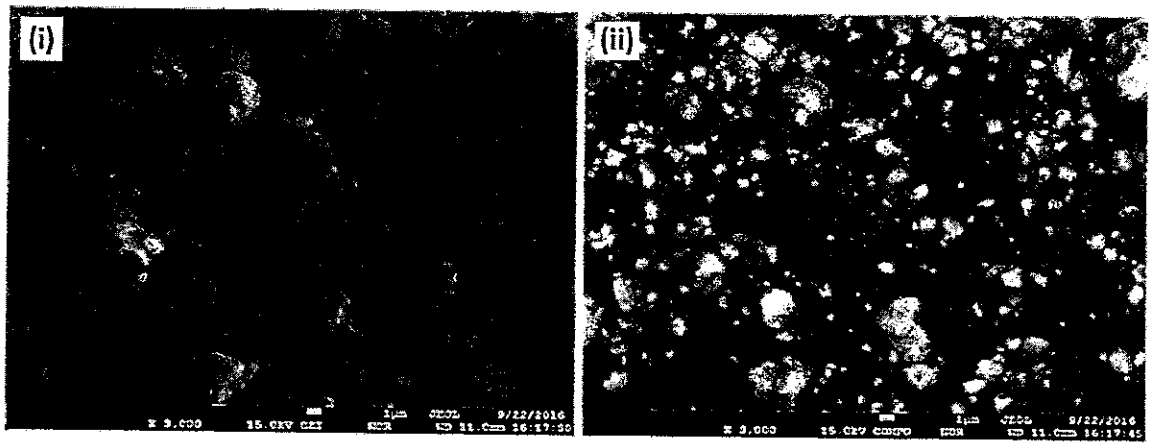

Figure Q4(a)
(Courtesy of K. Ma et al., 2017)

(b) **Figure Q4(b)** shows a sample that consists of magnetic domains indicated by the arrows. Draw a line curve, *magnetic force* as a function of *distance*, to represent the magnetic force distributions on the sample surface measured using magnetic force microscopy (MFM). Justify the formation of your line curve associates with the bright and dark contrast in the MFM image.

[5+6 marks]

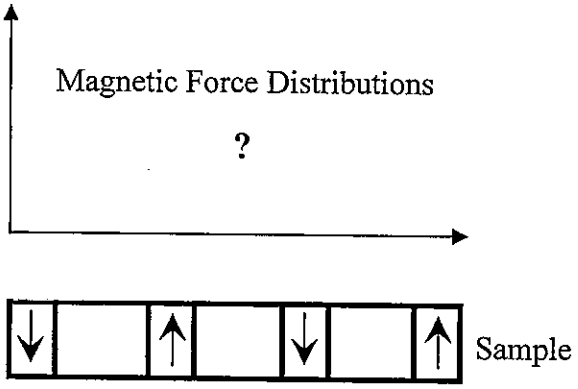

Figure Q4(b)

End of Paper